NASA CR- 160061

SOR0019Z

Final Report

NASA NAS5-22961

Schwarzschild Camera

Contents

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Final Report

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I. Summary

The primary and secondary mirrors for the GSFC designed Schwarzchild Camera have been fabricated. During the course of the contract, the optical design and performance of the Schwarzchild Camera was verified correct as provided in the work statement of the contract.

The null lens design was changed very slightly using glass FK-3 instead of FK-5 in the 3rd element. This lens was designed and toleranced and agreed in all essential ways to the GSFC design.

At first completion of the telescope, the wave front was on the order of one wave peak to peak at .63 microns. With reworking both mirrors, the system wave front was brought to 1/2 wave peak to peak error at .63 microns.

The fabrication procedure used is summarized here. Both mirrors were ground to a "best fitted" sphere. In this ground state, the mirrors were profiled with an electronic indicator traveling on a very accurate arc. The aspheric was generated in the ground state to the required indicator readings. When the mirrors were polished to an optical finish, the surface shape was to within .0001" of the final surface.

The secondary was hand corrected using a laser interferometer and the null lens. Upon completion of this step, both mirrors were etched in an acid solution. The optical surfaces and indexing holes were protected by wax. Approximately .017 inches was removed from exposed surfaces.

The primary mirror was now hand corrected in the telescope housing against the secondary mirror. The unit was twice passed with the light from a laser interferometer in an autocollimation arrangement.

The desired wave front for the telescope was 1/8 wave at .63 microns. The achieved wave front was 1/2 wave. These mirrors have a very steep departure from spherical. This makes it difficult to fit a lap over the required contour. This requires a small lap which in turn leaves sharp zones. Having brought the mirrors to 1/2 wave, it seems reasonable to say that with extra care at a few points along the way; it would probably be possible to achieve 1/4 wave. To achieve 1/8 wave with hand-figuring seems unlikely. The optician is continually battling zones and symmetry of the mirrors - losing one, while gaining the other. Also using a null lens to test the secondary does not allow the accuracy of a double pass null test as can be used for conic sections. The telescope system test is more demanding than the null lens test.

II. The Secondary Mirror

During the rework, the secondary mirror was found to have about 1/2 wave of asymetry. This was discovered by studying a series of interferograms in which the mirror was rotated versus the null lens. Figures 1 and 2 show a series of 3 pairs of interferograms made after the mirror was corrected. The resultant asymetry and figuring zones would be approximately 1/8 wave peak to peak error on the mirror surface.

This asymmetry probably arose in the beginning due to unbalanced hand figuring and slight miss alignment of the null lens test set up. It was corrected by spinning the mirror against a large, full sized fixed lap and by locally figuring selected areas of the mirror. We reached a point where it was uncertain if this mirror was asymmetric, the null lens asymmetric, or the test alignment slightly out. At this

level of accuracy, about 1/8 wave, the opticians result began to oscillate from good to bad and back. Some proportion of the 1/8 wave error visible in the interferograms is in the mirror. There will undoubtably be a resulting asymmetry in the off-axis resolution. The magnitude of this effect is impossible to predict based on our data.

III. The Primary Mirror (System)

Interferograms of the primary and secondary mirror as a system are shown in Figure 3. The system is double passed so that a fringe of error represents 1/2 wave, wavefront error. The system has 1/2 wave peak to peak error at .63 microns.

Secondary Mirror

in LUPI Test

12/26/78

A

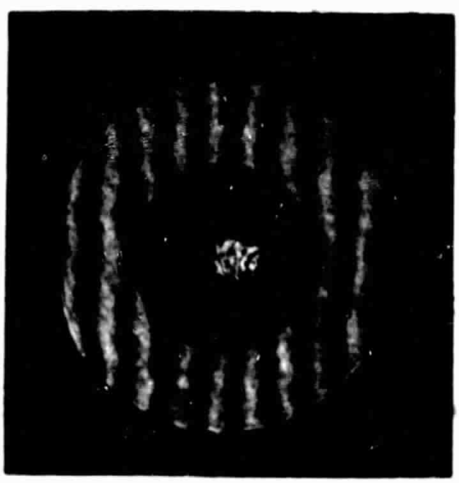
0°

Null Lens Rotated by 120°

12/26/78

B

120°



12/26/78

C

240°

Figure 1

Secondary Mirror in

LUPI Test

Null Lens Rotated by 120°

12/26/78

A

0°

12/26/78

B

120°

12/26/78

C

240°

Figure 2

Double Pass Interferogram

@ .63 microns of System

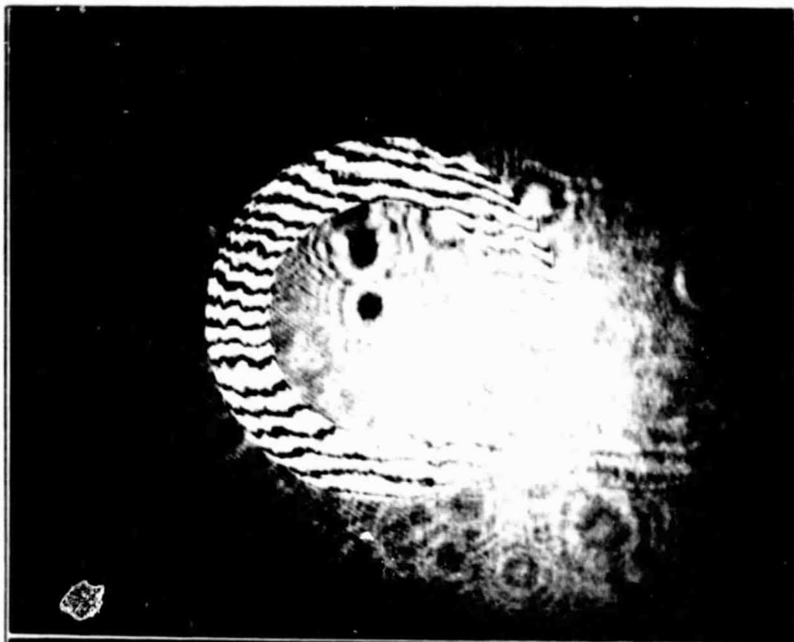


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Figure 3

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IV. Mounting Procedure - Primary Mirror

1. Position the primary mirror in it's cell on the three hemispherical support pads so that the two small holes in the back of the mirror line up with the alignment pin supports of the cell. See drawing No. 3002. The mirror is in the correct rotation when the numbers on the mirror back correspond with the numbers on the alignment pin supports.

2. The three threaded alignment screws behind the primary have been adjusted to their final position. The distances from their supports to the back of the mirror are: No 1 - .7842; No. 2 - .7840; No. 3 - .7902.

3. Two of the four radial clamps at the edge of the cell - those without holes - have been adjusted to their final position. The two screws with central holes should be tightened against the edge of the mirror. When the mirror is in its correct X-Y poistion, the distances from the outer support structure through the radial clamp screw holes to the edge of the mirror are: No. 1 .7250; No. 2 - .7403. See drawing No. 3003.

4. Fasten the mirror retaining ring to the cell.

5. Mount the cell in the support structure so that index marks on the support structure and upper flange of the cell coincide.

6. Insert three numbered cylindrical alignment pins in the corresponding radial holes of the support structure and cell. Insert nine tapered pins in the tapered holes.

7. Insert alignment pins and bushings 1 and 2 in the correct holes in the mirror back. See drawing No. 3002.

V. **Mounting Procedure - Secondary Mirror**

1. Position the secondary mirror in the lower bulkhead on the three hemispherical support pads so that the two small holes in the back of the mirror line up with the alignment pin supports of the bulkhead. See drawing No. 3002. The mirror is correctly rotated when the numbers on the back of the mirror correspond with the numbers on the alignment pin supports.

2. Shim around the mirror central hole to centralize the mirror in its mount, then tighten the four radial clamps and remove the shims. Note: The flanged face pads of the clamps have been improperly machined so that they must be shimmed to contact the mirror. The pads should be reworked before the final mounting.

3. Fasten the mirror retaining ring in place.

4. Mount the mirror and bulkhead in the support structure. The mirror is correctly rotated when the numbers on the bulkhead flange correspond to the numbers on the bushings of the three cylindrical pins located in the wall of the support structure.

5. Insert three numbered cylindrical alignment pins in the corresponding radial holes of the support structure and bulkhead. Insert nine tapered pins in the tapered holes.

6. Insert alignment pins and bushings 3 and 4 in the correspondingly numbered holes in the mirror back. See drawing No. 3002.

VI. Optical Alignment Procedure

Note: The unit has been critically aligned before shipment. If adjustments are preserved, it should return to this alignment when the parts are reassembled. In the event it does not, the following alignment procedure is given.

1. With the secondary alone mounted in the unit, use an alignment laser to autocollimate through the support tube from the window mounting surface.

2. Center the laser beam by putting a ground glass at the center of the curvature of the secondary and moving the beam until the spot is centered. A target placed in the window aperture will aid preliminary centering.

3. Transfer autocollimation to a high quality flat at least six inches in diameter placed behind the window aperture.

4. Put in the primary mirror and autocollimate it by holding a front surface mirror across the center hole on the optical surface.

5. Tape a small target on the optical flat centered at the laser beam.

6. Center the primary by putting a ground glass in the laser beam about five inches from the back of the mirror on the laser side. Look for an image at the target on the optical flat. Move the ground glass along the axis until the image is focussed. Move the centration of the primary until the focussed spot is on the center of the target.

7. A divergent fource placed 1.66 $\pm$ .02" behind the primary mirror should return on itself in autocollimation from the optical flat. If this is not the case, the air space of the primary and secondary must be adjusted.

The system may be evaluated by examing the image produced in this manner with a microsoope, interferometer, or other optical arrangement.

VII. 'As Built' Null Lens Data

The final measured values of the completed null lens are:

Surface Number	Radius	Thickness	Material	Index @ .63 microns
1	-5.553	.2132	FK-5	1.486351
2	6.830	.3955	Air	
3	-225.0	.1806	L F1	1.570336
4	11.246	.3849	Air	
5	204.0	.1793	FK-3	1.462988
6	3.628	17.1948	To Mirror	

From point source to surface #1 2.5992

Tolerances used were:

Wedge: .0002 TIR per element

Centration: .0002 TIR

Surface Accuracy: 1/10 wave